Europäisches Patentamt

European Patent Office

Office européen des brevets

(19)

(11) Publication number: **0 246 363**
A1

(12)   **EUROPEAN PATENT APPLICATION**

(71) Applicant: OGNIBENE OLMES
3, Via 7 Gennaio
I-42011 Bagnolo In Piano(IT)

(72) Inventor: OGNIBENE OLMES
3, Via 7 Gennaio
I-42011 Bagnolo In Piano(IT)

(74) Representative: Corradini, Corrado
STUDIO SECCHI & CORRADINI 4, Via Dante Alighieri
I-42100 Reggio Emilia(IT)

(54) Method and apparatus for weighing loads lifted by hydraulic devices.

(57) A method of weighing a load previously lifted by hydraulic devices, consists of carrying out an approximate weighing of the load at the end of the lifting phase, by determining the value of the weight from the pressure of the fluid which actuates the lifting of the load.

In a second step, a series of weighings is carried out, always based on the pressure of the hydraulic fluid after the load has been lowered for a period of time which is inversely proportional, in accordance with a linear function to the approximate weight of the load previously determined or is fixed independently of the load and is between 80 and 800 msec.

The average of the values of these weighings is determined and the values which differ by more than a predetermined amount are discarded.

The measurements are corrected according to a calibration table which is previously prepared for each apparatus.

Fig. 1.
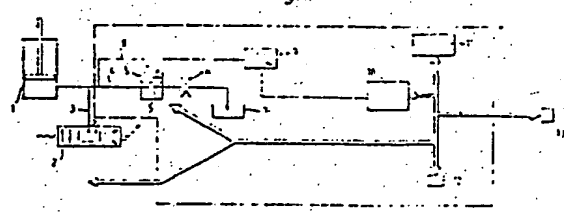
EP 0 246 363 A1

METHOD AND APPARATUS FOR WEIGHING LOADS LIFTED BY HYDRAULIC
DEVICES

5 The present invention relates to a method and an apparatus
which permit to measure in a very accurate manner, the weight
of loads which are lifted by hydraulic devices such as for
instance a dolly elevator.

10 It is well known that in many industrial and commercial sectors
the necessity exists of weighing substantial quantities of mate-
rial which may be finished products, merchandise and semifinished
articles.

15 This step of weighing is necessary for a number of reason, for
instance, to determine the overall price of the merchandise, to
determine the cost of labor of a substantial number of unfin-
ished or semi-finished items which are delivered to other com-
panies which will take care of the external transformations, to
determine the cost of transportation of the same quantity of mer-
20 chandise, to comply with the limits of the load of transportation
means and/or also for a correct listing of the documents which must
accompany the merchandise up to the place of delivery/unloading.

Up to the present time, the weighing of substantial quantities of
25 merchandise has been carried out by means of fixed weighing devices

which frequently are located at a substantial distance from the place where the merchandise to be weighed is located.

For the purpose of avoiding the substantial problems involved in a similar system of weighing, in view of the fact that these great loads or substantial quantities of merchandise are generally moved by means of hydraulic devices such as dolly elevators, the proposal has been made to carry out the weighing step simultaneously with the movement of the merchandise by means of the hydraulic devices.

According to known proposal, there is used a transducer of pressure which is associated with the flat car of the hydraulic device being used for lifting the merchandise, this transducer being capable of generating an electric signal proportional to the weight being lifted, the electric signal being then read after appropriate conversion on a scale which reports the weights of the merchandise.

The reading of the weight is carried out during the step of lifting the load, a fact which causes a very substantial inaccuracy in the measurements due to the inertia of the load being lifted and also the losses due to friction of the system.

For the purpose of avoiding this drawback, the proposal has been made to read the weight after a certain amount of time, that is when the flat car has completed the lifting course, so that it is possible to correct the losses due to friction through an appropriate calibration of the device.

The correction mentioned hereinabove, however, does not eliminate the errors due to the drawing of the fluid being used during the lifting step.

In fact, the flat car with its load, after it has come to a stop, is subject to an oscillatory condition during which forces of inertia which are not negligable play a substantial role and even after this condition has ended, the fluid drawn between the sealing
5 elements still causes an error in the value of the pressure.

This fact has made the known weighing devices which use this method essentially inoperative because it is practically impossible to have a sufficiently accurate reading of the weight instantaneously and
10 also after a certain amount of time gone by, the reading is not accurate.

One object of the present invention is to provide a method and an apparatus which permit to eliminate the drawbacks mentioned here-
15 inabove because the method and the apparatus permit to carry out a measurement of the weight essentially instantaneously with values which deviate from the real weight by an amount which is essen-tially negligible.

20 In accordance with the present invention, the method permits to carry out by means of a pressure transducer, a first approximate weighing of the load at the end of the lifting stage of the load, a weighing which does not take into account the forces of inertia and friction.
25

Then, in a second step, a series of successive measurements is carried out when the load is caused to be lowered for a period of time the duration of which is inversely proportional in a linear fashion to the value of the first weighing or it is fixed but
30 still comprised between 80 and 800 milliseconds.

The method also involves the step of mathematically filtering and

determining the average of the values of each series, leaving
out the values which differ from the average pressure by an
amount superior to a preestablished and acceptable reject value
which may be avaluated between 0.8% and 1.2% with respect to the
5   average value.

Finally, the method according to the present invention involves
the step of determining the average of the average values meas-
ured previously and comparing the result with a table which
10   gives the relationship between the pressure and the weight stored
in a processor and interpolating the values of the table in order
to determine the actual weight of the load.

This table is prepared by calibration for every type of machine
15   load or machines with known weights and proceeding according to
the above procedure.

In accordance with the method of the present invention, the suc-
cessive lowerings of the load have a duration of time which is
20   inversely proportional to the approximate value of the weight
of the load which has been lifted and this is for the purpose
of maintaining the effects of the forces of inertia of the masses
in motion contained in a limited field so as not to cause damage
to the pressure transducer.
25

In other words, during the stages of lowering the load, the fluid
which supports the load is subjected to forces of inertia and to
an impulse which is substantially constant no matter what the
weight of the load is and which may, therefore, be predetermined
30   with a good approximation.

Alternately, the successive lowerings may have a duration which

is independent of the load, but still comprised between 80 and 800 milliseconds.

5   It is, therefore, foreseen that each one of these series of successive weighings carried out at the end of an increment of time of lowering of the load be characterized by pressures which do not exceed the values tolerated by the transducer and this condition is maintained independently of the load.

10   In addition, the curves of the pressure during the oscillations of the transitory condition are all similar, with values which are the maximum and the minimum and with periods which are comparable among themselves.

15   The apparatus for carrying out the method according to the present invention comprises, according to the invention, a valve which is ordinarily closed and which is located along an unloading conduit, the latter being connected in parallel to the feeding branch of an hydraulic device for lifting the load such 20   as the cylinder piston group of a dolly elevator, as well as a reading element of the pressure which exists upstream of the same valve.

    This reading element is connected to an electronic circuit capa-
25   ble of converting and elaborating the signals emitted by the reading element and capable of imparting a command, after the lifting of the weight has come to a stop, to at least one opening of the valve for a period of time which is inversely proportional to the weight of the load which has been lifted.
30

    This valve comprises a precision electrovalve and a calibrated neck which is located downstream, the latter being capable of

avoiding that the load and the supporting structure acquire an

excessive speed when the valve is open.

In addition, the electronic circuit is connected to the valves

5 as mentioned hereinabove, as well as to the means for presenting

the weights which have been measured which are displayed visually

after the processor has provided for extrapolation of the value

of the curves of response described hereinabove and has provided

for the elimination of the friction forces of the system from the

10 measurements being carried out.

The present invention will be further clarified by the following

description and drawings in which Fig. 1 is a clock diagram of

the apparatus used to carry out the method of this invention.

15

Fig. 2 illustrates the relationship between the duration of time

and pressure.

Fig. 3 illustrates the change of pressure with time and shows

20 the diminishing oscillation with increase in time.

It should be stressed that the method and the apparatus of the

present invention may be used with every apparatus for lifting a

load no matter whether the apparatus is fixed or semimovable

25 where the lifting is carried out with an incompressible fluid,

for instance hydraulic oil.

For instance, a hydraulic device of this type is the device of

dolly elevators in which the fork is controlled by at least one

30 cylinder-oleodinamic piston group.

In any event, even if in the description which follows, reference

is being made specifically to a dolly elevator and to its component parts, this should not be construed as limiting the present invention because the method and apparatus may be adapted to any lifting device for a load involving the use of hydraulic
5   means.

In Fig. 1, numeral 1 designates schematically a group 1 which is a cylinder-oleodynamic piston and which is arranged upstream of the device (not shown) used for lifting and lowering the load
10 with the ordinary loading fork supporting the load as well as a hydraulic distributor 2 with a box for the command of the same group 1, this distributor 2 being connected to a hydraulic gear-box which provides oil under pressure (not shown).

15 Numeral 3 designates a conduit which connects group 1 to the distributor 2.

Tube 4 is connected to the conduit 3.

20 Along tube 4 are interposed a solenoid precision valve 5 as well as neck 6 downstream which is constituted of a calibrated orifice.

Tube 4 then unloads in reservoir 7 which contains the hydraulic
25 oil placed originally to actuate group 1.

In actual practice, tube 4 is connected in parallel to the feeding-unloading branch of group 1.

30 Upstream of the electrovalve 5, tube 8 is connected to tube 4.

Tube 8 is connected at its end with an electric pressure tran-

sducer 9 capable of converting the values of the pressure present
in 1 and 4 to an elctrical value proportional to the value of
the pressure.

5   Transducer 9 may be of every known type and the signals at the
exit may be in the form of current or voltage.

For the sake of clarity in Fig. 1, tube 8 is connected to conduit
4 at a point situated sufficiently away from group 1 but in actual
10   practice, tube 8 may be connected directly or may be very close
to group 1 for the purpose of minimizing the losses of the load
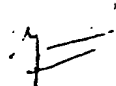due to the hydraulic circuits of the connection.

This transducer 9 is connected at the end to a converter 10 which
15   is constituted of a series of electronic circuits having high
resolutions.

These circuits are arranged to amplify the incoming electrical sig
nals and to convert the same from the initial analog form to a
20   digital form.

The latter is then carried to circuit 11 which is an electronic
processor circuit and to device 12 which displays the data.

25   As shown in figure 1, the processor circuit 11 is also connected
with electro-valve 5 and with sensors (not shown) provided in
the dolly elevator as well as with other accessory electronic
device which are generically designated by the numeral 13.

30   The processor circuit 11 is constituted by a microprocessor
having an integrated circuit having suitable devices for the
acquisition and transmission of data while the device for display

of the data is constituted by an electronic visual display which may be of the type having liquid crystals or photoemitting dials or an equivalent type.

5   In addition, the sensors mentioned hereinabove are means for detection provided on the carriage for reasons of safety and control for the purpose of avoiding erroneous measurements due to the apparatus when the dolly elevator functions in an irregular manner.

10

For instance, these sensors may include tracer points of stop for group 1; means of detecting eventual permanent deformations which occur on the mobile structure of the carriage and means of the constant control of the feeding voltage and absorbed cur-

15   rents, that is an auto-diagnosis circuit.

In addition, the devices designated by numeral 13 are accessory electronic devices which may include peripheral units for collecting and displaying information inherent to the measurements

20   carried out with the apparatus, for instance printing units, recorders, totalizers and units for the determination of the number of pieces which are accumulated in a random fashion in a load lifted by the carriage.

25   Other details with respect to units 10, 11, 12 and 13 are not being discussed herein because the characteristics and functions are well known to the people experienced in the field and who operate in the sector of acquisition/processing/transmission/ display of data.

30

The method of weighing in accordance with the present invention will be described hereinbelow keeping in mind the details dis-

0246363

cussed hereinabove and additional details which will be provided.

At the outset, the method is based on the principle that in the
case of an incompressible fluid, the pressure is transmitted
5   in an identical manner in every direction.

The method is also based on the fact that once the area on which
the pressure operates is known, it immediately follows to deduce
the force induced from the pressure in that area and vice versa.
10

Therefore, the useful section or the section of thrust of group
1 is a constant value which is stored in the memory of the pro-
cessor 11 and which constitutes the parameter which connect the
pressures to the forces which are the same as the weights to be
15   determined.

Further, in view of the fact that the measurements are carried
out when the load being weighed is in motion, as it will be
described hereinbelow, for the purpose of achieving a correct
20   measurement, it its necessary to account for both the force of
inertia, as well as the friction.

The apparatus described herein is adequate to carry out the
method according to the present invention as follows.
25

operation   When group 1 has completed the lifting of the forks on which the
load to be weighed is placed, the operator gives the weighing
command and by means of the group transducer/converter (9, 10),
Λ.   the processor carries out a first weighing of the load.

30

This value obviously is an approximate value due to the forces
of inertia of the load as well as of the structure of the car-

0246363

riage which supports the load and also due to mechanical friction and losses of load along the conduits of the fluid under pressure.

However, the extent of approximation of this first value of the
5   weight is sufficient to constitute the value expressed as pressure in the hydraulic jack which, after being processed the calculator, is converted into the duration of each increment of lowering of the load.

10 This duration is regulated by the following formula

$$T = h - k.P$$

in which T is the period of time expressed in msec (thousandths of seconds)

h is a constant having msec as dimension and may have a value
15 comprised between 500 and 2000

k is a constant having as dimension milliseconds/BAR and may have a value between 1 and 36

P is the pressure of the fluid in the elevator cylinder expressed in BAR.

20

This equation is illustrated in Fig. 2.

At the end of the lifting phase the processor 11 commands with signals the opening and the closing of the electrovalve 5, the
25 duration of each increment being determined by the equation indicated hereinabove as a function of the pressure relative to the first approximate weighing already stored by the processor 11.

30 Alternately, the duration of each increment may be fixed independently of the load but is always comprised between 80 and 800 msec.

According to the invention, the determinations of the values of
the pressure from which the weight of the load is derived, are
carried out when the load is stopped between one increment and
another increment.

5

When the load has stopped at the end of the increment, the pres-
sure (P) and the time (T) have a relationship according to Fig. 3
and follow an oscillatory decreasing curve.

10 The transducer begins reading the values of the pressure after
a period of time (A) comprised between 1 and 2 seconds and during
the period of time (B) which is about one second, carries out
at least 16 and preferably 40 readings.

15 Due to the formula hereinabove

$$T = h - k.P$$

which gives the duration of each increment of lowering as a func-
tion of the approximate weight of the load, at the end of each
increment the quantity m.v (mass times velocity) of the load is
20 about constant in spite of the variation of the mass (m) and,
therefore, the weight (P).

This occurs in every instance even if with minor approximation,
if the duration of each increment is between 80 and 800 m.sec.

25

The average of the readings of the pressure is then determined
and is measured after the period of time (A), that is after the
oscillations are almost damped because the values of the pres-
sure are initially selected to avoid eventual errors which are
30 likely to occur unavoidably.

From this operation of mathematical selection and average, there

are deduced at least eight values of pressure which are referred
to hereinbelow as (PA).

These eight values (PA) are then averaged obtaining a value (PM)
5   which is accepted for the successive elaborations only if it
does not differ from the values (PA) of a quantity in excess
of a prefixed reject value which is acceptable, which is between
0.8% and 1.2%.

10   In the contrary case, the measurement is disregarded.

The procedure as described hereinabove is repeated at least for
two successive increments and preferably for at least five in-
crements.

15

Then the arithmetical average of the values (PM) of each incre-
ment is calculated and this average is compared with the calibra-
tion table stored in the computer which gives the relationship
between pressure and weight.

20

This table interpolated by the calculator permits to read the
weight with an approximation of a few percents.

The calibration table is calculated for each machine carrying
25   out according to the procedure described hereinabove, the
weighing of known loads being done so that it is possible to
make an approximate calibration of the apparatus.

0246363

PATENT CLAIMS

1. A method of weighing a load previously lifted by a device actuated by at least one oleodynamic jack which comprises carrying out in an apparatus having a calibration table the following steps:

- Determining the values of the pressure (P) of actuation of the jack at the end of the lifting phase of the load, storing the said value of the pressure in a data processor;

- lowering the load at the end of the lifting stage by small increments, the duration of each increment being independent of the load and being between 80 and 800 milliseconds;

- carrying out at the end of each increment, after a delay of between 1 and 2 seconds, at least 16 determinations of the value of the pressure and transmitting said values to the processor;

- selecting mathematically and averaging said at least 16 values (PA) of the pressure in groups of at least two to obtain at least 8 decreasing values;

- averaging said eight values to obtain a value (PM) and discarding said value (PM) when it differs by an amount greater in percent than the value predetermined by each of said eight values;

- repeating said procedure at the end of each increment averaging the accepted values (PM) to obtain an average and comparing said average by interpolation with the table of calibration of said apparatus.

2. The method according to claim 1 wherein the duration of each increment depends on the load and the equation which controls the duration of each increment expressed in milliseconds and the pressure (P) expressed in BAR of the jack at the end of the lifting phase is:

$$T - h - k.P$$

where h is expressed in milliseconds and is comprised between 500 and 2000,

k expressed in milliseconds/BAR, is comprised between 1 and 36 and (P) is expressed in BAR.

3. The method according to claim 1 wherein the percentage value of the maximun discard predetermined as acceptable between (PA) and (PM) is 1.2%.

4. The method according to claim 1 wherein during the lowering phase of the load, a hydraulic braking is carried out whereby the losses of the load are maintained constant as to very small weights as well as substantial weights.

5. An apparatus for weighing a load previously lifted by a lifting device which comprises an oleodynamic jack (1), a conduit (3) connected with said jack for feeding and unloading said jack, a conduit (4) connected in parallel with said conduit (3), a valve (5), a neck (6) and a pressure transducer (9), a processor (11) being placed on said conduit (4), said processor (11) being capable of receiving through a converter A/D, the values of the pressure determined by said transducer (9) and being capable of processing said values and determining the value of weight of the load.

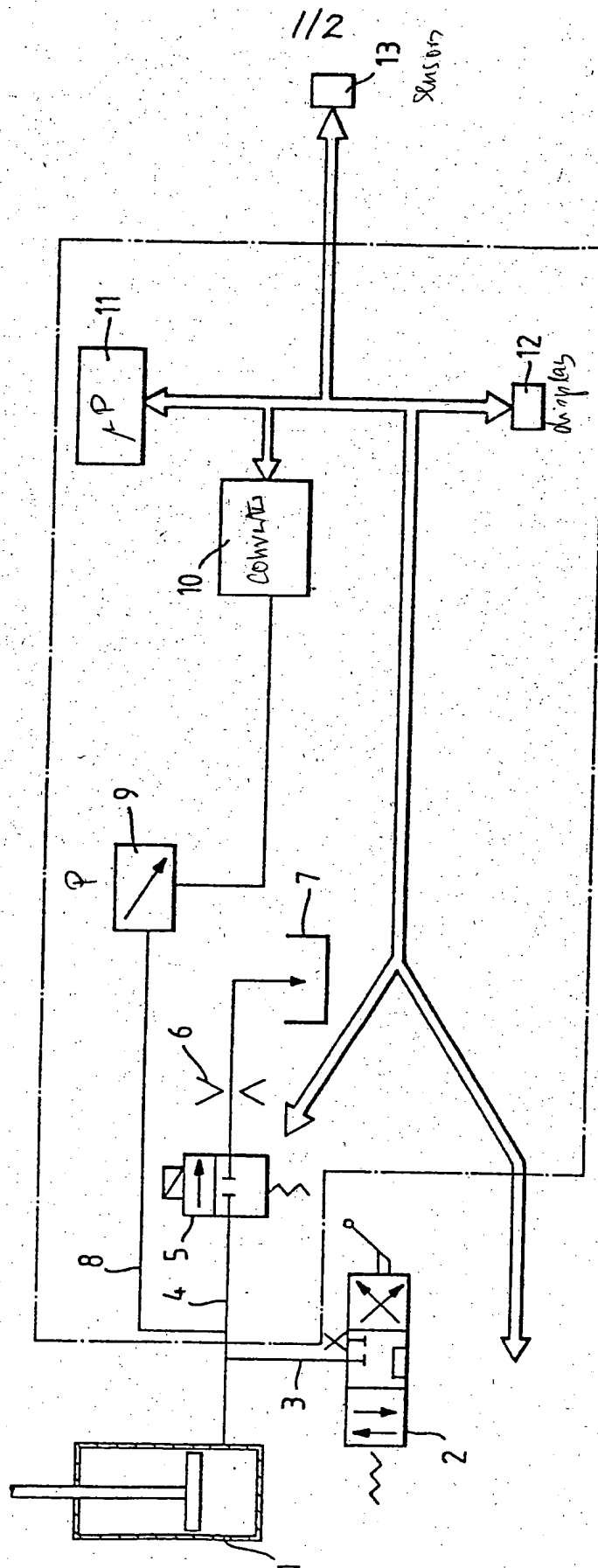6. The apparatus according to claim 5 wherein said processor (11) commands the opening and closing of said valve (5).

7. The apparatus according to claim 5 wherein said transducer (9) is an electrical transducer capable of converting the values of the pressure into proportional signals of voltage or current.
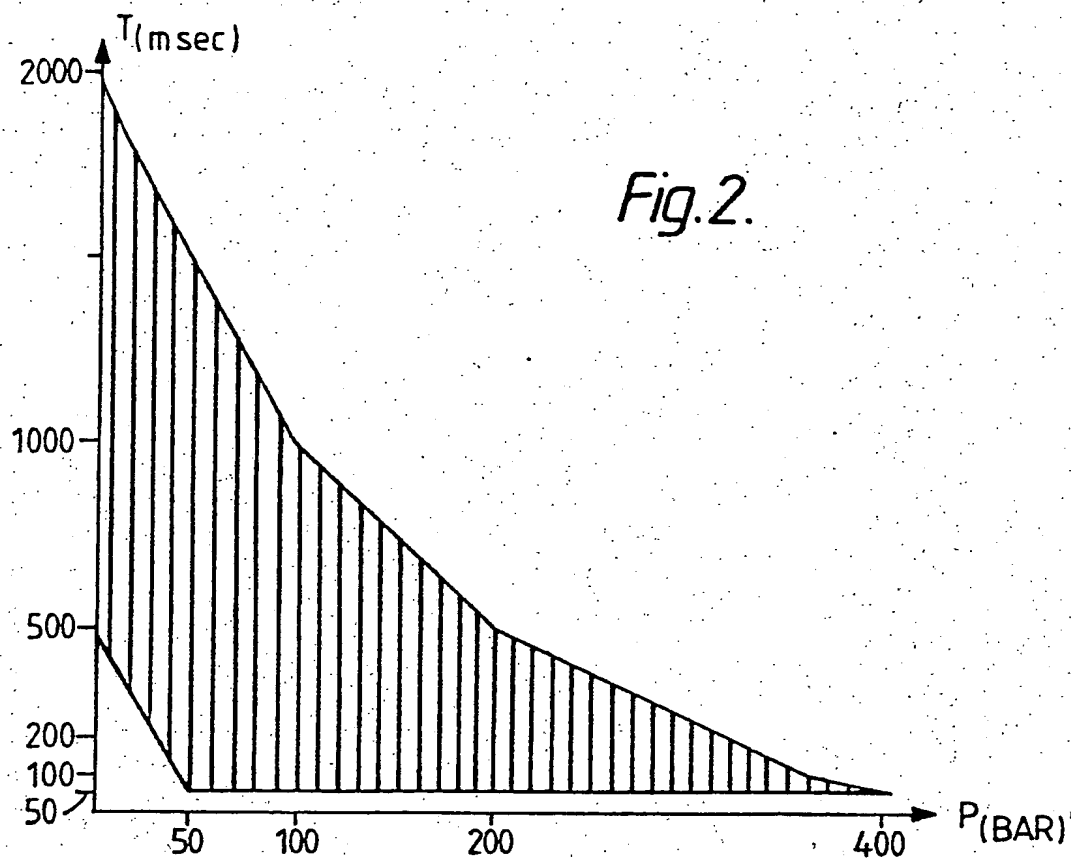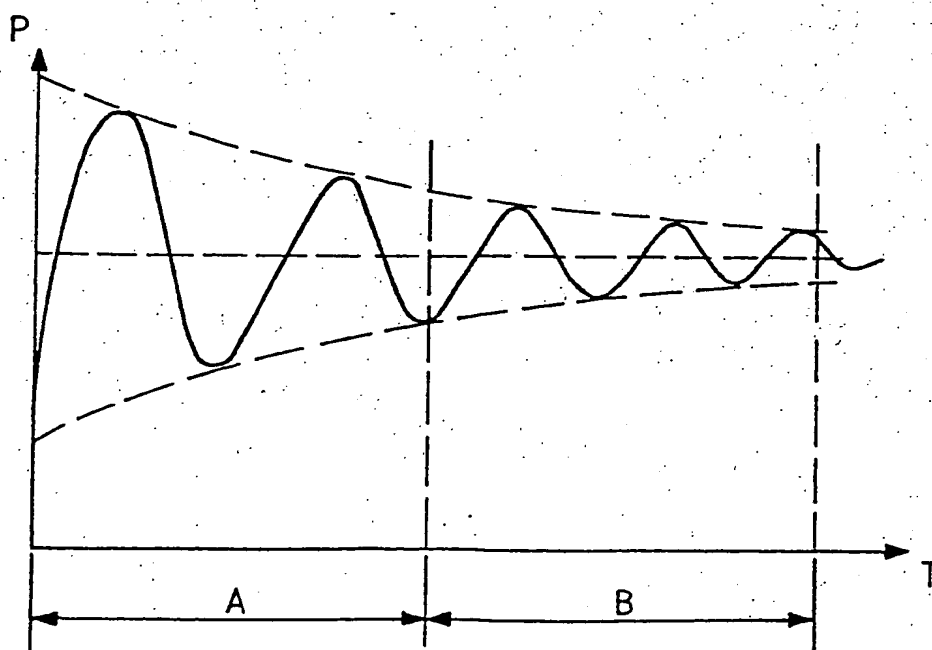
8. The apparatus according to claim 5 wherein said processor (11)

comprises means for storing the physicogeometrical data of the

lifting group (1) and is capable of storing the constants of ca-

libration of said apparatus and the signals transmitted by said

5   transducer (9) and is capable of storing the means of processing

of said data.

9. The apparatus according to claim 5 wherein said processor (11)

comprises a printing element (12) capable of showing the results

10 of the processor carried out as well as a unit (13) arranged pe-

ripherically capable of recording, totalizing and calculating the

results.

Fig.1.

0246363

Fig.2.

Fig.3.

European Patent Office

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
A	DE-A-2 364 335 (BACK) * Figure; claim 1 *	1,5	G 01 G 19/10
A	US-A-4 588 038 (TAKAGI) * Figure 3; abstract *	1,5	
A	PATENTS ABSTRACTS OF JAPAN, vol. 7, no. 90 (P-191)[1235], 14. April 1983; & JP-A-58 17 321 (FUJITA KOGYO K.K.) 01-02-1983 * Abstract *	1,5	

TECHNICAL FIELDS SEARCHED (Int Cl 4)

B 60 P
B 66 F
G 01 G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09-01-1987	MIELKE

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO Form 1503 03 82